FINAL REPORT

SELENIUM PROGRAM

GREAT SALT LAKE WATER QUALITY STUDIES

Development of a Selenium Standard for the Open Waters of the Great Salt Lake

STATE OF UTAH

DEPARTMENT OF ENVIRONMENTAL QUALITY

DIVISION OF WATER QUALITY

PREPARED BY

CWECS

CH2MHILL

215 S. State Street

Suite 1000

Salt Lake City, Utah 84111

APRIL 2008

1.0 Introduction

Great Salt Lake is of vital importance to resident and migratory birds, local recreation, and the brine shrimp and mineral industries. In recognition of this importance, and in response to increasing development pressures within the lake's watershed, the State of Utah initiated a program to complete research supporting the development of a site-specific selenium numeric water quality standard for the open waters of Great Salt Lake. This document summarizes this program and its recommendations.

This section of this document describes the physical setting of Great Salt Lake, the study area, lake conditions during the study period, and this document's organization.

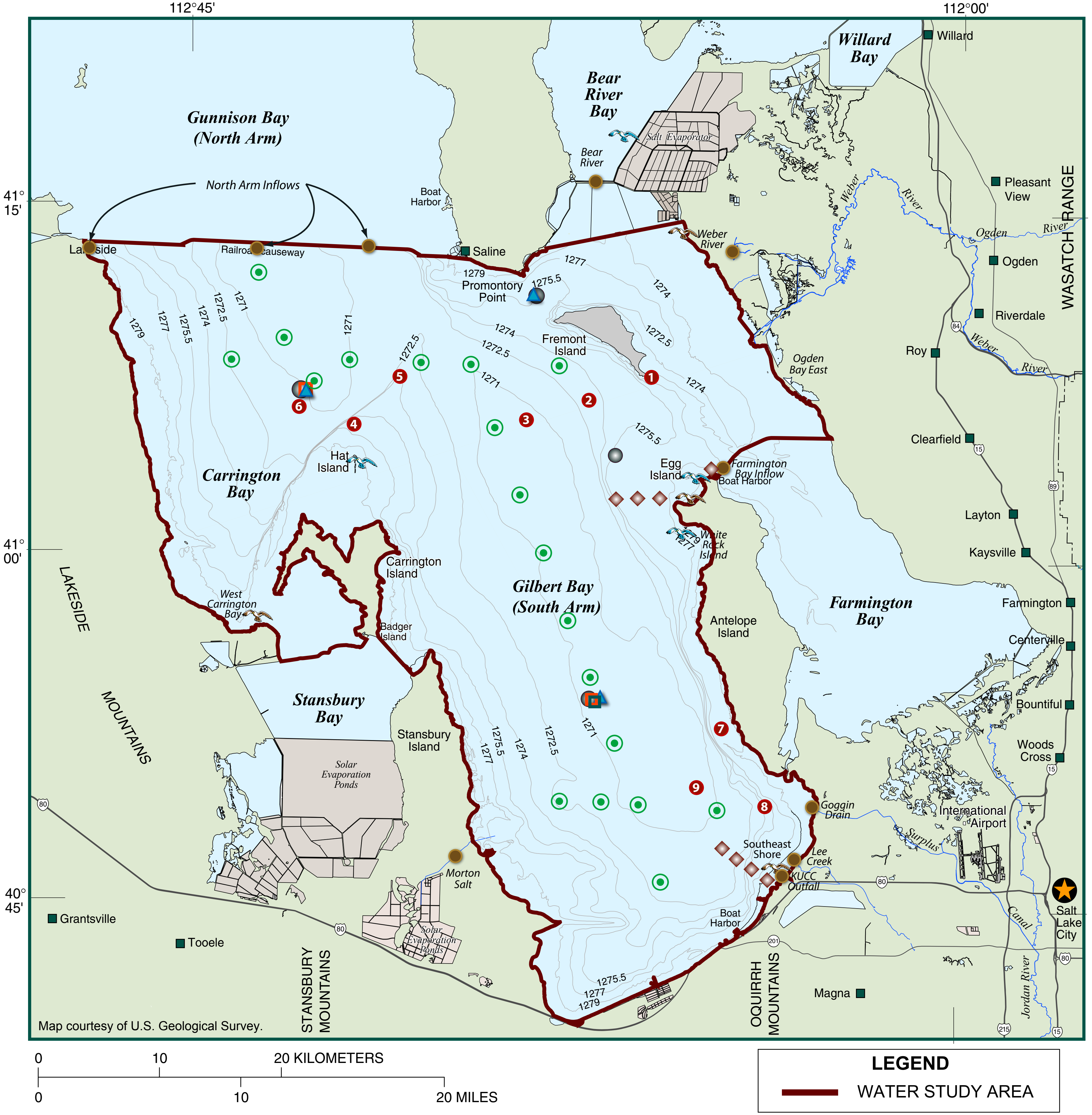
1.1 Physical Setting

Great Salt Lake is a uniquely dynamic terminal lake located adjacent to a rapidly growing metropolitan area in northern Utah (refer to Figure 1-1). Its approximate watershed area is 21,540 square miles, extending over three states, with an estimated population exceeding 1.9 million people in 2003. Population in the watershed is expected to increase by almost 75 percent by the year 2030 (Governor's Office of Planning and Budget, 2005). Changes in land use, hydrology, and water quality as a result of this population growth will add further dimensions of complexity to the lake's dynamics.

Great Salt Lake is the largest remnant of the ancient Lake Bonneville, which existed from about 32,000 to 14,000 years ago and once covered about 20,000 square miles of western Utah, eastern Nevada, and southern Idaho. A natural dam gave way about 16,000 years ago, resulting in a large flood that drained much of Lake Bonneville. Increased evaporation over the following millennia has led to the present-day Great Salt Lake, occupying the lowest depression in the Great Basin. As is characteristic of terminal lakes, Great Salt Lake has no outlet; water that flows in can only evaporate or percolate into the substrate.

Great Salt Lake is the sixth-largest lake in the United States and the world's fourth-largest terminal lake. It varies significantly in size and depth as a result of changes in inflow from precipitation, tributaries, and groundwater, as well as from losses through evaporation. At a lake elevation of 4,200 feet, the lake is about 75 miles long and 30 miles wide, and has about 335 miles of shoreline. It occupies more than 1,700 square miles and contains more than 15 million acre-feet (or almost 5 trillion gallons) of water. Great Salt Lake's shallow depths (its maximum depth is about 35 feet) and its gradually sloping shoreline result in dramatic surface area variations with any increase or decrease in lake level. Lake levels fluctuated more than 20 feet between 1873 and 1963, which had elevations of 4,211.5 and 4,191.35 feet, respectively. The lake's surface area fluctuated between 938 and 2,500 square miles in that same period (Hahl and Handy, 1969). The lake level rose 20.5 feet after 1963 to reach its record high level of 4,211.85 feet on June 3, 1986. The net rise between 1982 and 1986 was 12.2 feet (Arnow and Stephens, 1987).

THIS PAGE INTENTIONALLY LEFT BLANK



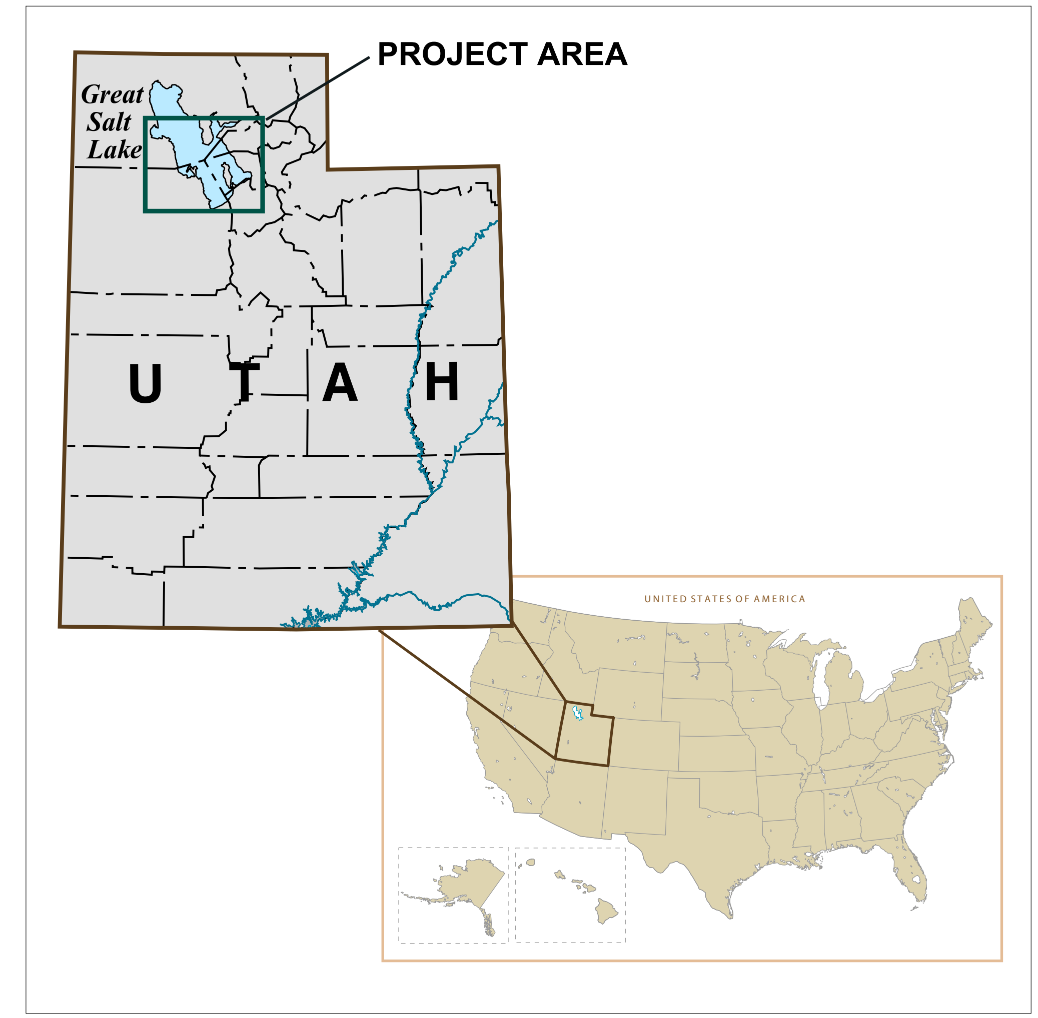


FIGURE 1-1
Study Area
Great Salt Lake Water Quality Studies
Final Report – Selenium Program

THIS PAGE INTENTIONALLY LEFT BLANK

On average, 2.9 million acre-feet of water and 2.2 million tons of salt enter Great Salt Lake each year. The vast majority of lake inflow typically comes from three drainages: the Jordan River (9 percent), Weber River (13 percent), and Bear River (39 percent). Additional inflow comes from groundwater (3 percent), direct precipitation (31 percent), and other minor east-side streams (5 percent) (Arnow and Stephens, 1987). Because the lake's only substantial water loss mechanism is evaporation, minerals, salts, and sediments from the watershed accumulate in Great Salt Lake. This results in lake water that is typically three to five times more salty than sea water and creates a unique habitat for biota that have adapted to and rely on the Great Salt Lake ecosystem.

1.2 Resources Dependent on Great Salt Lake

Great Salt Lake's unique yet harsh conditions are significant to the ecology and economy of the region and Western Hemisphere. Each of the lake's resources—including bird habitat, people, the mineral industry, and brine shrimp harvesters—maintains a fragile balance with the ecology of Great Salt Lake, often dependent on the annual conditions of the lake for its scale, diversity, and economic value.

Millions of birds use the lake as they migrate from breeding grounds as far away as the arctic to wintering areas as far away as Argentina. For example, up to 1 million Wilson's phalaropes (*Phalaropus tricolor*), or more than two-thirds of the world's population, annually migrate through Great Salt Lake as they travel from the near arctic to the high Andes (Jehl, 1988; Colwell and Jehl, 1994). The magnitude of the Wilson's phalarope population was a primary factor in the designation of Great Salt Lake as one of six sites within the Western Hemisphere's Shorebird Reserve Network in the United States (Aldrich and Paul, 2002). Over half of the world's population of eared grebes (*Podiceps nigricollis*) use Great Salt Lake for up to 4 months during fall migration (Jehl, 1988), and in 2007 their population on Great Salt Lake exceeded 2.5 million birds (N. Darnall, personal communication, October 15, 2007). Great Salt Lake hosts the largest nesting colony of American white pelicans (*Pelecanus erythrorhynchos*) west of the continental divide (King and Anderson, 2005) and the largest breeding population of California gulls (*Larus californicus*) in the world (Aldrich and Paul, 2002).

Opportunities for recreation abound on and around Great Salt Lake. Thousands of people visit the lake annually to enjoy sailing, hiking, hunting, and watching the diverse bird life. Along the lake are two state parks, numerous state wildlife refuges, and one federal wildlife refuge. Waterfowl hunting alone was estimated to be almost an $8-million industry in 1998 (Isaacson et al., 2002).

As a result of the minerals left behind by evaporation, Great Salt Lake is home to a burgeoning mineral industry that is perhaps the Great Salt Lake industry with the greatest impact on Utah's economy (Isaacson et al., 2002). Several mineral extraction companies currently operating on Great Salt Lake generated a total of about 2.8 million tons of sodium chloride, potassium sulfate, magnesium chloride, magnesium metal, chlorine gas, and other products—all estimated to be worth about $300 million in 1995 (Gwynn, 1997). This represents about 16 percent of the annual value of all minerals produced in 1995 in Utah (U.S. Geological Survey [USGS], 1995).

Great Salt Lake produces a significant portion of the world's supply of brine shrimp cysts. Commercial harvest on the lake began in 1952 and the lake has become an internationally renowned source of cysts for their quality as feed for the aquaculture and ornamental fish industry. The market value is estimated to average $8 to 11 million annually with an estimated peak value of $58 million in 1995. The annual harvest from Great Salt Lake is often limited by biological factors rather than market forces (Isaacson et al., 2002).

1.3 Study Area

Figure 1-1 shows the study area referred to as the "open waters of Great Salt Lake" for this project. This area is commonly referred to in the literature as Gilbert Bay or the South Arm, and includes Ogden Bay and Carrington Bay within its area (Gwynn, 1987). Farmington Bay, Gunnison Bay (also known as the North Arm), Bear River Bay, Willard Bay, and Stansbury Bay are not included in the study area.

The study area is generally bounded by the shoreline as defined by the current lake water level but an area no greater than as represented by the lake's bed elevation of 4,202 feet (Moellmer, 2007, personal communication). The Union Pacific Railroad Causeway separates Gilbert Bay from Gunnison Bay and Bear River Bay. The Antelope Island Causeway and Island Dike Road at the southern end of Antelope Island separate Gilbert Bay from Farmington Bay. A series of evaporation pond dikes separate Gilbert Bay from what was historically known as Stansbury Bay.

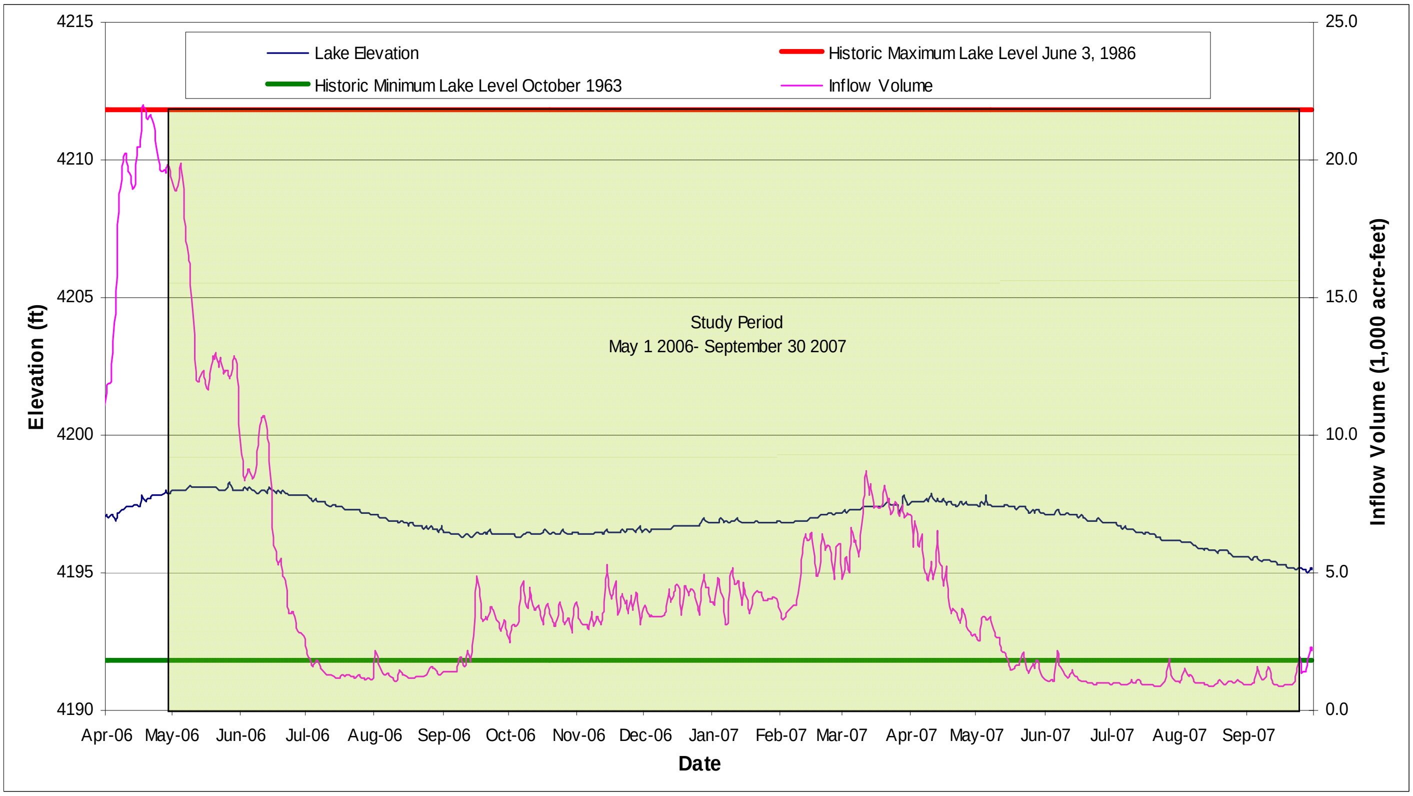
1.4 Lake Conditions during the Study Period

As previously described, Great Salt Lake is a uniquely dynamic water body dependent on a wide variety of variables that affect its physical characteristics. While an objective of this selenium program is to characterize the cycling of selenium in Great Salt Lake, it is important to understand the context of the research in terms of the historic variability of the lake and its watershed. Field studies for this program began in May 2006 and generally ended in September 2007.

1.4.1 Lake Level

The lake elevation for the study period, as measured at the USGS station at Saltair (USGS 10010000 Great Salt Lake at Saltair Boat Harbor, Utah), varied from 4,198.0 feet on May 1, 2006 to 4,195.1 feet on September 30, 2007 (see Figure 1-2). The maximum lake elevation in the study period was 4,198.3 feet (May 27, 2006) and the minimum elevation was 4,195.0 feet (September 28, 2007). As noted earlier in Section 1.1, the lake elevation has historically fluctuated more than 20 feet with a maximum elevation of 4,211.85 feet in 1986 and a minimum elevation of 4,191.85 feet in 1963.

FIGURE 1-2
Lake Elevation and Inflow Volume throughout Study Period



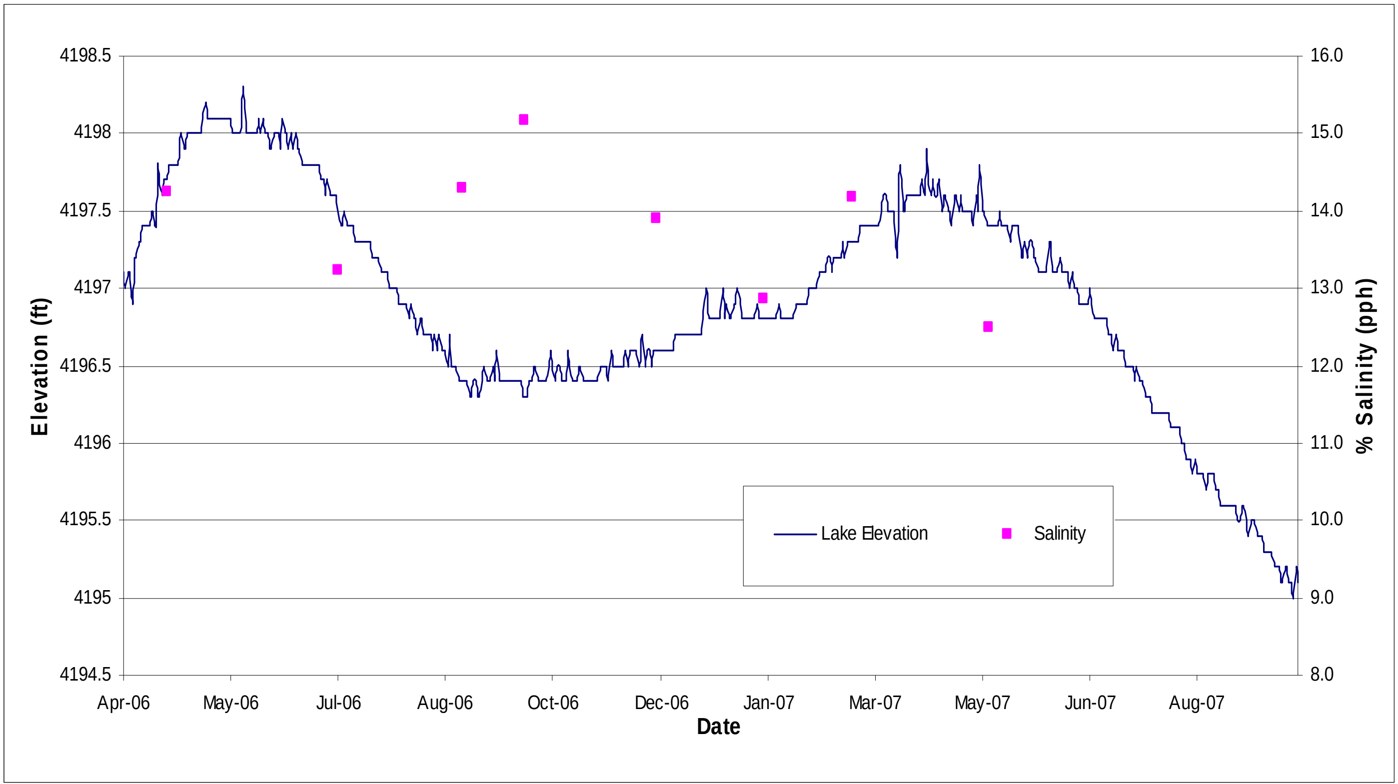
1.4.2 Surface Area and Volume

The surface area and water volume of the study area for the study period varied from an area of 743 square miles and volume of 8,273,227 acre-feet on May 1, 2006 to an area of 659 square miles and volume of 6,908,632 acre-feet on September 30, 2007 (as estimated from the elevation/volume relationship of Baskin [2005]). This represents a reduction in surface area of about 11 percent and a reduction in volume of about 16 percent over the study period. The lake's surface area varied between 2,500 and 938 square miles between 1873 (similar elevation as in 1986) and 1963, respectively (Hahl and Handy, 1969).

1.4.3 Salinity

The USGS monitors the salinity of Great Salt Lake at 16 locations on a monthly basis. The salinity for the study period, as measured by the USGS, varied from 14.2 percent in April 2006 to 12.5 percent in May 2007. The maximum measured salinity in the study period was 15.2 percent and the minimum measured salinity was 12.5 percent. See Figure 1-3 for salinity values plotted along with lake elevations for the study period. The lake's salinity generally varies inversely with lake level and has historically varied between 5.6 percent in 1986 to 28 percent in 1963 (Arnow and Stephens, 1987).

FIGURE 1-3
Lake Elevation and Salinity

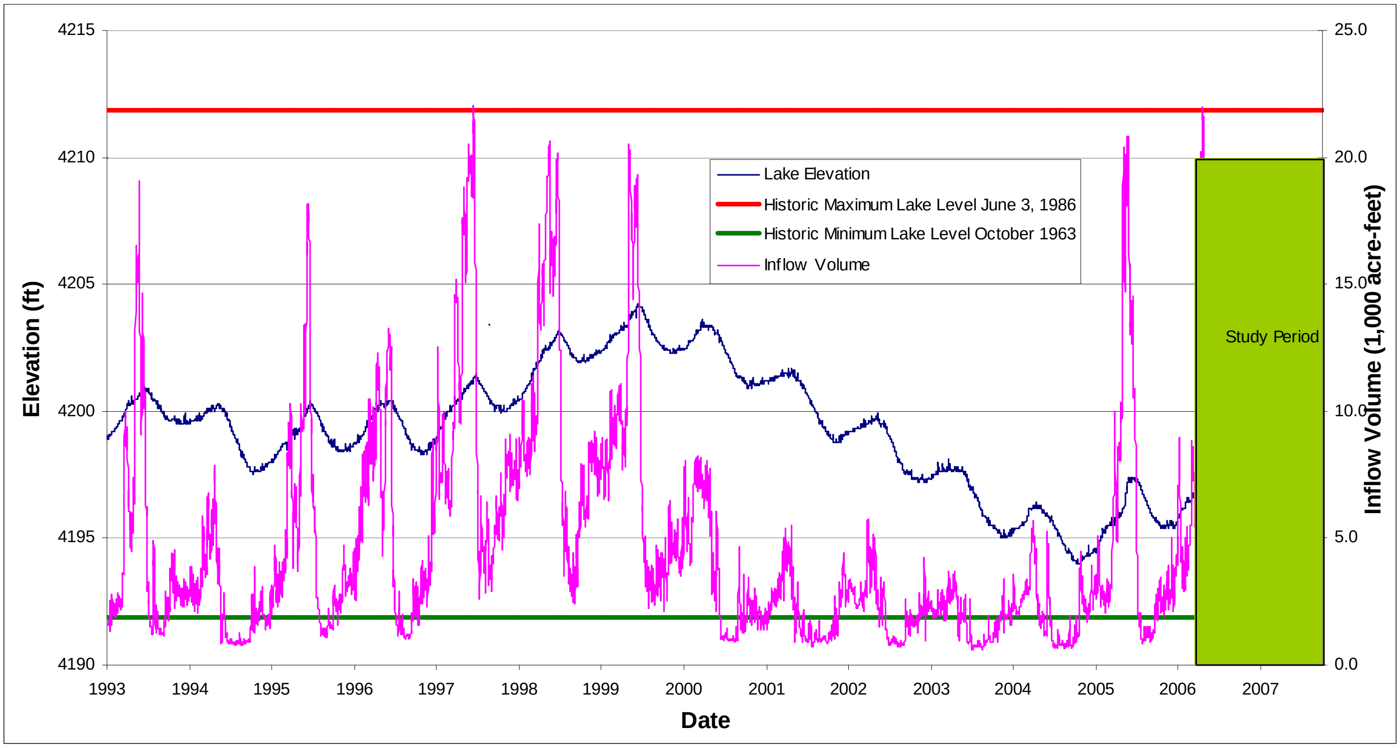


1.4.4 Hydrology

The elevation, size, and salinity of Great Salt Lake vary largely as a result of changes in inflow from precipitation, tributaries, and groundwater, as well as from losses through evaporation. Understanding the watershed's recent hydrologic regime helps to place the lake's response during the study period in context.

The study period (May 2006 through September 2007) provided a unique opportunity to understand the dynamics of Great Salt Lake during a dry period of the hydrologic cycle. The two indices used by the State of Utah to define and compare cumulative drought events, the Palmer Drought Severity Index (PDSI) and the Palmer Hydrologic Drought Index (PHDI), indicate that the watershed moved into a drought condition during the study period (Utah Division of Wildlife Resources, 2007). Great Salt Lake's watershed had a PDSI and PHDI in May 2006 that indicated "moderately moist" to "very moist" conditions in the watershed. This is consistent with the generally "wet" water years of 2005 and 2006. Throughout the study period, however, conditions consistently became drier within the watershed and the PDSI and PHDI at the end of the study period in September 2007 indicated "severe drought" to "extreme drought" condition in the watershed (National Oceanic and Atmospheric Administration, 2007). These effects of the dry cycle can also be observed in Figure 1-4; lake levels generally decreased during the study period as inflow volumes decreased. While the effects of a drought period upon the cycling of selenium in Great Salt Lake are not understood, it is certainly a variable that affects the dynamics of the lake.

FIGURE 1-4
Lake Elevation and Inflow Volume 1993 - 2007



1.5 Document Organization

The remainder of this document is divided in the following sections:

- Section 2.0 provides the historical background of the project, regulatory framework, and need for a numeric site-specific water quality standard.
- Section 3.0 describes the development of the Utah Division of Water Quality's (UDWQ's) public involvement, consultation, and coordination program and the development of the overall selenium program.
- Section 4.0 defines the objectives for the overall selenium program and for each of the individual projects.
- Section 5.0 provides a summary of the program's quality assurance protocol and the results and conclusions for each of the seven projects.
- Section 6.0 provides a summary of the considerations, assumptions, and methodology used to develop a quantitative model of selenium cycling in the open waters of Great Salt Lake.
- Section 7.0 provides a summary of the results of the conceptual model for each of the alternatives selected by the Science Panel and provides an initial "palette" of the values for consideration as the site-specific standard for selenium.

- Section 8.0 identifies considerations and recommendations for implementation of a new selenium water quality standard for the open waters of Great Salt Lake.
- Section 9.0 provides a summary of this report and offers conclusions based on the presented information.
- Section 10.0 provides references cited in this document.

Final reports and other pertinent technical memoranda prepared as part of this program are included in the appendices of this document.

- Appendix A, Conceptual Model for Selenium Cycling in the Great Salt Lake
- Appendix B, Threshold Values Memoranda
- Appendix C, Project 1A - Shorebirds
- Appendix D, Project 1B – Gulls, Grebes, Ducks
- Appendix E, Project 2A - Benthic Zone and Brine Flies
- Appendix F, Project 2B - Pelagic Zone and Brine Shrimp
- Appendix G, Project 3 - Selenium Loads to the Lake
- Appendix H, Project 4 - Selenium Flux within and from the Lake
- Appendix I, Project 5 - Brine Shrimp Kinetics Study
- Appendix J, Data Validation Report
- Appendix K, Avian Blood Memo
- Appendix L, Evaluation of Mercury Concentrations in Birds Collected from Great Salt Lake, 2006 and 2007

2.0 Program Background

2.1 Historical Perspective

Great Salt Lake and its shores have been the subject of management deliberations arguably since the first Mormon pioneers settled near its shores in 1847. These deliberations historically centered primarily upon resource use and allocation. Increasing development of those resources in the latter part of the 20th century shifted that focus towards defining the ecological resources of Great Salt Lake and protecting them. What was first considered a relatively simple ecosystem composed of algae, brine shrimp, brine flies, and bird life, was discovered to be a very complex and dynamic ecosystem. It rapidly became apparent that the lack of a comprehensive database describing the complex ecosystem made it very difficult to make management decisions resulting in its protection (Atwood et al., 1999).

State and federal agencies historically have collected a significant amount of information characterizing lake level fluctuations, water balance, and salt balance throughout Great Salt Lake. While appropriate for some management decisions, additional information was needed to understand the ramifications of those decisions on the Great Salt Lake ecosystem. The State of Utah completed the Great Salt Lake Comprehensive Management Plan in 1997 and updated it again in 2000 (Great Salt Lake Planning Team, 2000). The State of Utah initiated the Great Salt Lake Ecosystem Project in 1994 to work towards understanding the ecology of Great Salt Lake (Stephens and Birdsey, 2002).

The Ecosystem Project and other efforts have worked to understand:

- How the algal growth rate, competitive interactions, abundance, and species composition fluctuate as they relate to salinity, temperature, and nutrient influxes
- How brine shrimp survival and reproduction fluctuate with salinity, temperature, nutrient influxes, algal abundance and species composition, and predation from other zooplankton
- Great Salt Lake bird species—both their numbers and how they use lake resources
- The complex limnology of Great Salt Lake as it relates to salinity, temperature, lake levels, water balance and mixing, and contaminant and nutrient influxes

It has been found that these processes do not operate independently but interact and seem to vary—sometimes significantly—from year to year (Atwood et al., 1999). These studies confirmed that Great Salt Lake's ecosystem is unique and much more complex than previously thought.

2.2 Existing Regulatory Framework

The federal Water Pollution Control Act Amendments of 1972—also known as the Clean Water Act—established the institutional structure for the U.S. Environmental Protection Agency (EPA) to regulate discharges of pollutants into the waters of the United States, establish water quality standards, conduct planning studies, and provide funding for specific grant projects. The Clean Water Act has been amended by Congress several times since 1972. The EPA has provided most states with the authority to administer many of the provisions of the Clean Water Act.

The UDWQ has specified appropriate beneficial uses for waters of the State and achieve and protect those uses through the development and enforcement of water quality standards (40 *CFR* §131.11). Due to the unique geochemistry of Great Salt Lake, the application of national fresh-water selenium water quality criteria to Great Salt Lake is inappropriate (EPA 1987, 2004). The open waters of Great Salt Lake have instead been protected for their beneficial uses through the application of the following narrative criteria clause in the State water quality standards (R317-2-7):

> *7.2 Narrative Standards*
> *It shall be unlawful, and a violation of these regulations, for any person to discharge or place any waste or other substance in such a way as will be or may become offensive such as unnatural deposits, floating debris, oil, scum or other nuisances such as color, odor or taste; or cause conditions which produce undesirable aquatic life or which produce objectionable tastes in edible aquatic organisms; or result in concentrations or combinations of substances which produce undesirable physiological responses in desirable resident fish, or other desirable aquatic life, or undesirable human health effects, as determined by bioassay or other tests performed in accordance with standard procedures.*

The beneficial uses designated for Great Salt Lake are listed in R317-2-6, Use Designations and summarized in Table 2-1.

TABLE 2-1
Beneficial Uses of Waters of Great Salt Lake

Beneficial Use
Primary Contact Recreation
Secondary Contact Recreation
Waterfowl, Shorebirds, and Other Water-Oriented Wildlife
Aquatic Food Chain Organisms
Mineral Extraction

The narrative standard has been implemented by the State of Utah in part through requiring that any discharges to fresh water tributaries must meet fresh water numeric water quality standards. Any discharges directly to Great Salt Lake are required to meet background concentrations in the lake, or the State has required the discharger to complete site-specific studies to establish a protective numeric standard (Ostler, 2004).

Kennecott Utah Copper Corporation completed studies from 2000 to 2002 establishing a site-specific water quality standard for selenium that would be included as part of their Utah Pollution Discharge Elimination System (UPDES) discharge permit to Great Salt Lake (Brix et al., 2004). These studies evaluated the potential bioaccumulation of selenium in aquatic-dependent birds (such as shorebirds and waterfowl) from their diet of brine shrimp, and indicated that the bird diet (for example, brine shrimp) should not exceed 5 milligrams of selenium per kilogram (mg Se/Kg) to be protective. Applying that dietary selenium threshold for aquatic birds to the relationship between water and brine shrimp tissue levels resulted in an estimate of 27 micrograms selenium per liter (µg Se/L) as a safe concentration in water for this exposure pathway. Therefore, the narrative standard is interpreted to mean that a "de facto" chronic numeric standard for selenium in Great Salt Lake is 27 µg Se/L. This is the value the UDWQ currently uses in assessing and enforcing UPDES discharge permits to Great Salt Lake (UDWQ fact sheet, 2004a).

2.3 Need for a Site-Specific Standard

Mining and other activities in the southwestern Salt Lake Valley have resulted in groundwater with elevated sulfate concentrations that threaten the integrity of an important municipal water supply. Under federal Superfund Law and provisions of Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), the State of Utah and its partners developed a joint proposal to develop and construct a groundwater extraction and treatment project, with groundwater remedial functions, to provide treated municipal-quality water to the public in southwestern Salt Lake Valley. The proposed reverse osmosis (RO) treatment processes that remove the contaminants also generate a concentrated brine requiring disposal.

Some of the RO concentrate was initially proposed to be discharged to the Jordan River. A UPDES discharge permit to do so was obtained from the State of Utah. Under its UPDES permit, remaining RO concentrate was to be recycled by the Kennecott Utah Copper Corporation with excess water discharged to Great Salt Lake. As a result of public comments focusing primarily upon selenium concentrations in the RO concentrate, the UPDES permit for discharge to the Jordan River was withdrawn and efforts were renewed to find an alternative disposal location for concentrate waters to be produced from the treatment process (Jordan Valley Water Conservancy District, 2006).

After evaluating 15 alternatives, the stakeholder forum recommended that discharge of the concentrate to Great Salt Lake be considered following additional research and verification that discharge of such concentrate will not be harmful to the Great Salt Lake ecosystem. Selenium was the primary constituent of concern. The State of Utah subsequently convened the Great Salt Lake Water Quality Steering Committee (Steering Committee), consisting of key stakeholders similar in structure to the stakeholder forum discussed previously, and an expert Science Panel to recommend a new selenium water quality standard for the Great Salt Lake. Information developed from that process will serve as the basis for further public comment and to determine if regulatory approval of a UPDES permit for discharge of the concentrate to Great Salt Lake is feasible. The stakeholder forum is expected to reconvene and make its final recommendation after a site-specific water quality standard is in place (Jordan Valley Water Conservancy District, 2006).

2.4 Development of a Site-Specific Standard

Site-specific water quality standards that reflect the unique biota, habitat, and geochemistry of a water body are allowed by federal and state regulations. The Clean Water Act provides states with the opportunity to adopt water quality standards that are "…modified to reflect site specific conditions" (40 *CFR* §131.11[b][1][ii]). Site-specific standards are intended to account for species composition and water quality characteristics at the site and result in better levels of protection to aquatic life at the site than national criteria. The State of Utah rules also provide for the development of site-specific numeric water quality standards:

> *The Board may allow site-specific modifications based upon bioassay or other tests performed in accordance with standard procedures determined by the Board* (State of Utah, 2007b).

Federal regulations require that states submit to the EPA the "methodologies used for site-specific criteria development, any general policies applicable to water quality standards, and any revisions to the standards" (40 *CFR* §131.20[c]). In addition, water quality criteria must be based on "sound scientific rationale" (40 *CFR* §131.11). Lastly, states should establish numeric standards "based on Clean Water Act Section 304(a) Guidance modified to reflect site-specific conditions, or other scientifically defensible methods" (40 *CFR* §131.11[ii],[iii]; see also the EPA's Water Quality Standards Handbook [1994], Chapter 3, Water Quality Criteria).

The approach for development of a site-specific standard for selenium in the open waters of Great Salt Lake is atypical for several reasons. The EPA typically derives water quality criteria for aquatic organisms (that is, it does not directly address aquatic-dependent wildlife), the EPA applies toxicity data that are based on water-column concentrations and result in direct effects on test organisms (that is, it does not directly address dietary exposure), and it derives criteria that are presented as water column concentrations (Wuerthele, 2004). For selenium in Great Salt Lake, there are a number of factors that are not ideally addressed by the typical EPA protocol, such as the following:

- Selenium is a bioaccumulative toxicant, with dietary exposure as a key pathway.
- Chronic selenium criteria, therefore, are appropriately presented as threshold tissue-based values.
- Although the aquatic community in Great Salt Lake is rather limited, it is an important resource for aquatic-dependent birds.
- For Great Salt Lake, potential effects on aquatic-dependent birds must be a key consideration in standard development.
- The chemistry of Great Salt Lake is unique.

Furthermore, the EPA's typical approach to aquatic life criteria development requires a minimum dataset with data to include a range of functional groups and sensitive taxa (such as a salmonid, a second recreationally or commercially important fish family, another aquatic vertebrate, a planktonic crustacean [for example, cladoceran], a benthic crustacean [for example, amphipod, an aquatic insect, etc.]) to derive acute and chronic criteria (Wuerthele, 2004).

The current national ambient water quality criteria (EPA, 1987) are based on a number of studies at Belews Lake, North Carolina, with the chronic criterion set at 5 µg Se/L (total recoverable selenium). More recently (EPA, 2004), EPA has proposed draft criteria that are based on whole-body fish tissue (chronic value equals 7.91 µg Se/g dry weight) based on a winter stress study with bluegill. That chronic value is not appropriate for Great Salt

Lake for a number of reasons (absence of fish, etc.), so the site-specific standard must be based on conditions applicable to the lake (as described in Section 3.0).

Past efforts to develop water quality standards for selenium for Great Salt Lake have focused on dietary exposure as a key pathway to waterfowl and shorebirds that feed there. As described previously, this is due to the bioaccumulative nature of selenium, and resulted in a suggested chronic selenium criterion that was expressed as a threshold tissue-based value (Brix et al., 2004). Potential effects of selenium concentrations in these kinds of birds will play an important role in the development of a new Great Salt Lake site-specific selenium standard. Given the unique chemistry and limited dataset describing the Great Salt Lake's ecology, site-specific selenium standards will have to consider other factors, such as the following (Wuerthele, 2004):

- A key aquatic organism will need to be identified for which a tissue-based value may be developed.
- A tissue-based toxicity threshold value for the aquatic organism will need to be evaluated and determined that will protect wildlife dependent on that aquatic organism as a food resource.
- The evaluation should include an assessment of whether the whole-body toxicity threshold value will be protective of critical endpoints in wildlife, such as reproductive success.
- A relationship will need to be derived to allow the translation of a tissue-based toxicity threshold concentration to a water column concentration. This will be required for use as a basis for regulating discharges to Great Salt Lake.
- Accurate and precise methods will be needed to measure selenium in Great Salt Lake water and in tissues of aquatic organisms.

Pursuant to the lack of an adequate understanding of the fate of selenium in Great Salt Lake and the requirements identified above, the State of Utah initiated the current program to complete the requisite scientific research to develop a numeric water quality standard for the open waters of Great Salt Lake.

THIS PAGE INTENTIONALLY LEFT BLANK